May 20th, 12:15 PM - 12:45 PM

Wilson-Cowan coupled dynamics in a model of the cortico-striato-thalamo-cortical circuit

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Abstract

The neuronal circuit that controls the execution of stereotyped behaviors involves three major regions of the brain: the cortex, the striatum and the thalamus (the CSTC pathway). Coordinated interplay between activation and inhibition within the CSTC pathway is crucial for proper thought-processing and movement execution. However, there is no clear understanding of basic mechanisms generating hyperactivity in the CSTC pathway – a hallmark feature of patients with increased anxiety and motor activity, like the ones affected by obsessive compulsive disorder.

We build a coupled nonlinear model of neural and synaptic activity, that captures salient information in the CSTC circuit provided by electrode recordings and optogenetic studies in rodents. Using methods from nonlinear dynamics and bifurcation theory, we study the system's temporal behavior and its dependence on parameters. We verify and interpret current molecular theories on the role of CSTC regulation in the formation of obsessions and compulsions.